DOCUMENT RESUME

ED 154 922 PS 009 939

AUTHOR Hunt, J. McVicker
TITLE Relevance to Educability: Heritability or the Range of Reaction.
PUB DATE Oct 77
NOTE 33p.; Paper presented at the Conference on the Rights of Children (University of Illinois, Urbana, Illinois, October 28, 1977)

EDRS PRICE MF-$0.83 HC-$2.06 Plus Postage.
DESCRIPTORS Achievement; Adoption; *Children; Compensatory Education; Cross Cultural Studies; Early Childhood Education; *Early Experience; Environmental Influences; Heredity; *Intelligence; Intelligence Quotient; Language Development; *Nature Nurture Controversy; Personality; *Research; Research Design; Social Values; *Values
IDENTIFIERS Educability; Heritability; Project Head Start

ABSTRACT

This paper advocates that assessments of children's educability should utilize strategies based on a paradigm of plasticity of intellect within a wide range of hereditary limits rather than on a straightforward heritability paradigm. The relationship between science and values is discussed and the role of each in the creation of Project Head Start is delineated briefly. The failure of Head Start to achieve its middle class achievement goals for poverty children is portrayed as the basis for a conceptual backlash which has brought hereditary theories of intelligence back into contention. The concept of heritability (that proportion of the variance in any measurable phenotypic characteristic attributable to the variation of genotypes within the population) is examined in detail and its lack of relevance to the concept of educability is argued. The concept of range of reaction (that variation in any observable, measurable phenotypic characteristic that a given genotype can produce in response to variation in the environment or life experience) is discussed in detail. The major portion of the paper presents data illustrative of a research strategy suggested by the concept of the range of reaction. Data reported include empirical and anecdotal data on the language, achievement and personality of children from an orphanage in Tehran and a brief review of related cross-cultural and adoption studies. (JMB)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED154922

U S DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

RELEVANCE TO EDUCABILITY:

HERITABILITY OR THE RANGE OF REACTION*

By J. McVicker Hunt

University of Illinois

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

J. McVicker Hunt

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) AND USERS OF THE ERIC SYSTEM."

*This paper was presented orally at the Conference on the Rights of Children: Priorities in Research, 28 October 1977, University of Illinois. The Waters Foundation provided support for its preparation, and I wish to acknowledge this support with gratitude.

-- PLEASE DO NOT QUOTE WITHOUT PERMISSION --

PS 009939

RELEVANCE TO EDUCABILITY: HERITABILITY OR RANGE OF REACTION

J. McVicker Hunt

University of Illinois

Today, I wish to discuss the rights of children in the strategy to be employed in assessing educability. The validity of my message is dependent on what I believe to be a proper relationship between science and values. On the one hand, the validity of knowledge demands that the investigative process of science must be value-free. By that, I mean that logical analyses, the selection of data, the collecting of data, the processing of data, and the drawing of conclusions in science must be as free as possible from our wishes. Science concerns what _is_ what, not what we wish it to be. Values are a source of wishes. One very important reason for keeping the process of science value free is to obtain accurate knowledge. The accuracy of knowledge is very important for the effectiveness of our efforts to achieve the adaptive and civilizing goals that we value.

On the other hand, it is inevitable that human needs and values will influence what gets investigative attention. In 1941, J. G. Crowther wrote a book called _The Social Relations of Science_ which shows that the challenges of each age since the Renaissance have dictated which domains of reality got investigated. Thus, it is our values which determine what we investigate and with what vigor. Moreover, values can quite properly combine with knowledge to influence decisions on which strategy is most relevant to valued goals with a given domain. The argument to follow presumes this second relationship between science and values. Finally, new knowledge can also make established values relevant to domains for which they have previously had no clear relevance. In so doing, new knowledge can be a major basis for social change. In a speech to the board of directors of the Day Care and Child Development Council of America, Daniel Moynihan (1969) put the matter of this third relationship this way: "When radical (_i.e._, social) change takes place, it comes through knowledge, not slogans, not simply enthusiasm, but through the impact of knowledge" (as quoted in _Voice of Children_, 2(10), p. 3). It must be added that whenever knowledge results in social change it is always tied up with values.

This third relationship of science to values is illustrated by the roles of knowledge and values in the launching of Project Head Start. So long as the social Darwinism of Herbert Spencer and William Graham Sumner held sway in the United States (see Hofstadter, 1945), people generally believed the view promolgated by Francis Galton (1869) that intelligence is essentially fixed and the view promulgated by G. Stanley Hall and his student, Arnold Gesell (1954) that psychological development is predetermined by heredity. So long as such beliefs prevailed, the value of equality of opportunity, handed down by the founding fathers, had no relevance to the inequities of the preschool years for those children who had the bad luck to be born to parents in poverty without education. On the other hand, assembling the evidence of plasticity in early psychological development and combining it with evidence fo class differences in child rearing clearly made the value of equality of opportunity highly relevant to these inequities of the preschool years. In _The Children's Cause_, Gilbert Steiner (1976) credits my book, _Intelligence and Experience_ (1961) and Benjamin Bloom's (1964) _Stability and Change_

Human Characteristics with assembling the evidences of plasticity and of the role of early experience in psychological development in such a way as to make them reasonably convincing.

While such knowledge clearly made the value of equality of opportunity relevant to the inequities in development-fostering experience across the social-class structure, the influence of these books in the political arena was a matter of accident. It depended upon Presidents Kennedy and Johnson having launched a War on Poverty for reasons I need not go into here. It depended, second, on the fact that Kennedy had a mentally-deficient sister which seems to have motivated a special concern for such matters. (Parenthetically, since they are often used interchangeably, I would like to distinguish between mentally deficient, . . a deficit in development and competence due to pathology, and mentally retarded, a descriptive term for delayed development without reference to causation. I wish to keep these two terms separate with these differing meanings.) President Kennedy appointed his sister's husband, Sargent Shriver, to the directorship of the Office of Economic Opportunity. The Sargent Shrivers had chosen as their pediatrician a physician who had fathered a mentally-deficient child. This physician, Dr. Robert Cooke, was asked to chair the White House Task Force on early child development which recommended the establishment of the National Institute of Child Health and Human Development to promote research and, at the same time, recommended Project Head Start as an agency for action in this domain. At the time, Robert Cooke wrote Director Schriver that, "There already exists adequate understanding of the problems and processes involved to permit an immediate and massive intervention in the poverty cycle." Congress approved this recommendation, and Project Head Start was launched in 1965. The knowledge of developmental plasticity and of class differences in the development-fostering quality of early experience made the value of equality of opportunity highly relevant to the inequalities of opportunity during infancy and the preschool years. The advent of men of family relationships with persons mentally deficient or retarded coming into political power augmented the political importance of the value and brought forth support for both research and social action.

It is the fate of Project Head Start, however, that gives me the springboard for my message. Project Head Start had three main kinds of goals. One was health. Toward this goal, what Frankenberg has described in this symposium as largely untested screening devices were devised and employed. The second goal concerned community action. An effort was made to provide people from the poverty sector with more opportunity for influence on their own lives and their own institutions than they had ever had before. The third goal was educational. Here the hope was to compensate the children, and particularly those from the poverty sector, for the deficiencies in the development-fostering quality of the experience of their first four years, and to do it with a summer or a year of nursery schooling. This, in gist, was the arrangement. It was also mandated that the program be evaluated for its effectiveness.

When the evaluative studies were made, first by the Civil Rights Commission in 1967 -- which was a weak study -- and then by the Westinghouse Report by Cicarelli's (1969) group at the Ohio University -- a stronger and more influential study -- the focus was on the educational goals. I dare not take the time here to recite the details. The upshot is that participants in Head Start programs exhibited greater scholastic progress than did non-participants from similar backgrounds

while the programs were in progress. On the other hand, they failed to achieve the unrealistic goal of catching up with those from middle-class families. Moreover, those gains made during the Head Start year tended to disappear with time and nearly all were lost by the end of the first grade. Against the unrealistic hopes for Project Head Start, these outcomes tended to damn the whole enterprise.

The principle reasons for this so-called failure are easy to see. It is one thing to have knowledge that a given kind of reform should be possible; it is quite another one to know with precision how to effect it successfully. What we did in Project Head Start was to deploy the most prevalent kind of nursery schooling available. This kind had been developed under the influence of psychoanalytic thought for the children of affluent parents, who could pay for it. The goal was to enable such children to escape for part of the day from their over-controlling mothers so that they would not develop such strong superegos as to make them neurotic. This statement may be somewhat unfair, but it helps make the point that the nursery-schooling deployed was poorly fitted to achieve the compensatory educational purpose of Head Start. When Head Start was launched, no tested technology of compensatory education existed. A good many of us who were most concerned feared that the goals and expectations for the project were unrealistic. We would have preferred to begin with a program to develop a tested technology of compensatory education before launching such a large-scale program of service.

A second reason for the so-called failure was based upon our attempt to achieve the community-action goal by means of a "grass-roots" administrative philosophy which brought parents from the poverty sector directly into the Head Start programs as paraprofessional aides in administration, teaching, and transportation. The result, all too often, was chaos (see Payne, Mercer, Payne & Davison, 1973). This is another reason that the kinds of experiences provided to the children of Head Start programs were poorly calculated to achieve the compensatory educational purpose.

A third factor is somewhat moot, but I believe it has to be considered as an hypothesis. It is Epstein's (1974a, 1974b) hypothesis of phrenoblysis -- growth spurts of the brain and the mind -- for which there are two kinds of evidence. The examinations of the gains that children make in head size show spurts which occur during ages 2-4, 6-8, 10-12, and 14-16 years of age. Epstein has found similar spurtsof gain in the IQ which come during the same periods as those for head size. From such evidence, Epstein has suggested that there are periods in the course of development in which the brain grows more rapidly than does the soma as a whole, and that it is during these periods of especially rapid growth or welling, that a child can most rapidly achieve new knowledge and skills. I have taken this hypothesis seriously enough to examine the evidence from the Parent and Child Centers and the evidence from the Follow-Through Program of Head Start. It is true that the size of the gains one finds during the period from 4 to 6 years of age are smaller than those gained earlier or those gained later. While other factors could well account for such consonant findings, it may also be that Project Head Start was launched at the least fortunate age possible to achieve its compensatory educational purpose.

Now the hopes created by the combination of the knowledge of plasticity in early development and the appreciation of experiential inequities that launched Project Head Start also launched a renaissance in developmental psychology with investigations of the variations in early experience across the social classes and

attempts to improve the technology of compensatory education. These are not, strictly speaking, part of Project Head Start, but they do represent social gains from the Zeitgeist. Moreover, any gains toward the Head Start goals of health and community action have never been assessed. When I wrote Julius Richmond in 1964 to question the wisdom of launching such a large-scale service program as Project Head Start without first developing a tested technology of compensatory education, he answered that the health gains alone would easily justify the project. It seems to me that there is a lesson here for the policy makers. They should demand that evaluative investigations mandated should obtain evidence of effects relevant to all of the goals of a reform.

REACTION TO THE SO-CALLED FAILURE OF PROJECT HEAD START

Despite such weaknesses, this so-called failure of Project Head Start has prompted a revisiting of these old beliefs in intelligence being essentially fixed and development being predetermined by heredity. In his well known paper entitled "How Much Can We Boost IQ and Academic Achievement?", Arthur Jensen (1969) opened with this sentence: "Compensatory education has been tried and it apparently has failed." The remainder of his paper is concerned with why. In a long discourse on heredity and heritability, he finally comes up with the proposition traditional in textbooks of psychology before World War II, namely, approximately 80% of the variance in the IQ is hereditary. Hence, only 20% of the total variance is left. So not much of an effect can be expected to result from compensatory education. This is the gist of his argument.

Jensen also argues that racial and social class differences in performance on tests of intelligence and academic achievement are also largely hereditary. This argument from Jensen (1969, 1972, 1973) supported by the authority of Nobel Prize Physicist William Bradford Shockley and the partial support of Richard Herrnstein (1971, 1973), has rearoused the emotionality of the old harangues of the relative influences of heredity and environment which I had thought "by the board," Not so, for this paper of Jensen's was discussed by the Nixon cabinet in some detail (Hirsch, 1975, p. 4), and it may well have been important in reducing the Nixon administration's enthusiasm for both the Office of Economic Opportunity and for Project Head Start. Furthermore, it has reinstated the vitriol in debates over heredity and environment and evoked tremendous hostility on campuses (see prefaces in: Jensen, 1972; Herrnstein, 1973). Let me turn next to some definitions and definitional discussions.

SOME DEFINITIONS

Heredity is the process through which living beings in reproducing pass the determiners of their basic characteristics from generation to generation. Genetics is the science through which this process is investigated. I shall make no attempt to synopsize a course in genetics here, but a few concepts are important.

The determiners of characteristics are genes, the units of genetic material. Each gene controls a biochemical step in metabolism. Genes (DNA and RNA) are arranged in linear chains called chromosomes, and their arrangement regulates the sequences of metabolic paths that lead in still poorly understood fashion from a fertilized ovum to a mature member of a species. The historical story of the gene from its introduction as a logical construct, termed a Merkmal by Gregor Mendel, a factor by William Bateson, and finally, a gene by Johannsen (1909), through its physical identification with the electron microscope, to the double-stranded model of DNA of Watson and Crick (1953) is one of the most dramatic stories of modern science.

In human beings, the nucleus of each cell contains 22 pairs of chromosomes called autosomes with an additional pair of sex chromosomes. In women, the two sex chromosomes are similar, but in men they are different. One of these sex chromosomes in the male is full size, and it determines femaleness. The other is minute and determines maleness. As somatic cells divide, each chromosome of each pair divides and reduplicates itself. In the production of germ cells, ova and sperms, on the other hand, there is a reduction process in which the chromosome number is exactly halved. Each sperm and each ovum gets one of the chromosomes from each of the pairs present in each of the somatic cells. When a sperm enters an ovum in fertilization, each brings its compliment of 22 autosomes plus the sex chromosome into a new pairing. It is through this reduction andcoming back together that the fertilized ovum which constitutes the beginnings of a new human organism has a genotype composed of chromosomes and genes from both parents. Whether the new human organism will be female or male depends on which kind of sex chromosome carried by the sperm enters the ovum.

The genotype is the complement of chromosomes and genes which holds the determiners which guide the metabolic sequences in the maturation of the new individual. It was Johannsen (1909) who distinguished the genotype, which is the complement of observable and measurable characteristics of the new individual, from the phenotype. Traditionally, we have treated such measures as the IQ as if they concerned inherent genotypic potential. Actually, of course, a test can measure only a phenotype which is the product of the individual's genetic constitution as it has developed in the course of adaptation to the circumstances, biochemical, physical, and social, encountered in the course of living. It is not the environmental circumstances per se, however, that influence development. Rather, it is the changes that occur within theorganism in the course of the adaptive efforts which are important. These adaptive efforts constitute the experience of the developing organism. It is thus that I dislike using the term environment; I much prefer to use the term experience. When I do use the term environment, I shall include in its meaning the coping efforts elicited. Thus, the so-called effects of environment are the accumulation of themodifications in sensorimotor organizations, knowledge, and skills which come about through these efforts to adapt and cope.

Heritability, a key term for my message, refers to that proportion of the variance in any measurable phenotypic characteristic in the progeny from a population of individuals which is attributable to heredity, or, more precisely, to the variation of genotypes within the population. This is merely a definition. The process of assessing heritability calls for a methodology with assumptions. These assumptions are tricky because the influence of heredity and of experience are

typically confounded in families. In view of this tangle, various methodologies for separating the influences of heredity and experience have been used.

Perhaps that most direct is one employed in animal husbandry where the idea of heritability has a long history. I grew up on a farm. One of our operations was a dairy. There we were continually concerned to improve the milk crop. A standard method is to select for breeding purposes those cows of a given breed with milk production well above average: say, for example, the top 3% that give, on the average, 5 gallons a day. To make the illustration simple, let us say that the average yield for the breed is 3 gallons a day, and that the standard deviation of the yield is one gallon. This means that our sample selected for breeding purposes averages 2 standard deviations above the mean in yield. We find that their offspring yield an average of four gallons of milk a day. Thus, they remain well above the average for the breed; in fact, their yield is one standard deviation above the average. This direct assessment of heritability is obtained by dividing the selection gain (i.e., one standard deviation) by the selection differential (i.e., 2 standard deviations). The result, for these illustrative data, is .5 or 50%. Such a direct measure of heritability can be expected to hold, however, for only an identical sampling of genotypes reared under exactly the same set of conditions.

With human beings, investigators have employed an indirect strategy for separating the intertwined influences of heredity and experience. In essence, this indirect strategy consists of statistical comparisons of the size of the correlation between pairs of individuals with differing degrees of genetic relationship. Those most commonly used for such comparisons are the correlations between monozygotic or identical twins with the correlations between dizygotic or fraternal twins. I shall make no attempt here to take you through the mathematics of the formulae for heritability (h^2), but shall merely refer you to some of the papers (see Holzinger, 1929; Fuller & Thompson, 1960, p. 68; Vandenberg, 1966; Jensen, 1967). For our purposes, these indices of heritability may be considered equivalent to percentages of variance in the IQ attributable to heredity, or more precisely, to the variance in the genotypes in the pairs of subjects sampled. The values of these "percentages" in Jensen's (1967, p. 300) table range from a low of 42 to a high of 93, and the mean is 68. Nevertheless, Jensen revisits the estimate of 80% which was traditional in the textbooks of psychology before World War II. He obtains this mean from the data summarized by Erlenmeyer-Kimling and Jarvik (1963) "which represent the median values of all the twin studies reported in the literature up to 1963" (Jensen, 1967, p. 301). This mean is also based on the assumption of a genetic correlation of 0.25 between pairs of parents and therefore a genetic correlation between siblings of 0.55. Parenthetically, by a somewhat different set of statistical assumptions, Jencks, et al., (1972) have come up with a value of 45 per cent as seeming "to come closer to explaining the overall pattern of correlations between relatives and non-relatives than does either a higher or lower estimate," but debates over the size of the percentage of variance in the IQ attributable to heredity is irrelevant to my message.

EDUCABILITY FROM HERITABILITY

Two statements can be made about estimates of educability derived from such indices of heritability. First, they are at best indirect when a direct approach to the assessment of educability exists, as we shall see. Second, and at any rate, such estimates of educability are meaningless because indices of heritability are essentially irrelevant to educability. Now, let me explicate these statements.

Estimates of educability based on indices of heritability are indirect because they are derived from subtracting the percentage of variance due to heredity from the total variance in the IQ. Thus, such estimates of educability must come indirectly from subtracting an indirect assessment of theinfluence of heredity on the variance in the IQ from the total variance in the IQ. This strategy assumes the additivity of these influences of heredity (H) and of experience (E). Put in mathematical form, H + E = 100%, so 100% - H = E. If H = 80%, then 100% - 80% = 20%, and the influence of heredity is of theorder of four times that of experience.

This approach to the assessment of educability not only piles indirect assessment on indirect assessment, but it assumes the additivity of the influences of heredity and experience. This assumption, originally made by R. A. Fisher (1918), is itself highly questionable (Hogben, 1939; Loevinger, 1943; McGuire & Hirsch, 1977, p. 40ff). It is highly questionable because, as I have pointed out elsewhere (Hunt, 1961), neither heredity nor environment operates directly on such measures of behavior as the IQ, and because "it is highly unlikely that either heredity or environment are properly regarded even as scales, not to say scales based on family income, the vocabularies of father and mother, the Whittier scale, etc" (p. 329). As already noted, each of the various genes must influence behavioral measures indirectly through the metabolic paths that each of the genes controls (Beadle, 1945). It is conceivable that genes may influence what is measured by tests of intelligence in affecting, for instance, the proportion of the brain that is unconnected with either receptor inputs or motor outlets (something akin to Hebb's (1949) A/S ratio) or biochemical balances that help determine the ease with which cerebral systems are modified by experience. But such influence need be no monotonic function of the proportion of the genes shared by related individuals. Moreover, the presumption of additivity assumes, in turn, the absence of interaction between the influences of heredity and experience, and genetic research has turned up many findings, beginning with the original ones of Johannsen (1909), to disprove this assumption. In general, these findings show that the influence of differing environments varies with different genotypes (see Hirsch, 1970; Hunt, 1961, pp. 330-332). At best, then, any statement about the educability of individuals based on assessments of heritability are doubly indirect, and each indirection involves assumptions that are palpably false.

Assessments of heritability are basically irrelevant to the educability of individuals or groups because each such assessment, by definition, holds only for the particular sample of genotypes and of environments or life histories on which it is based. The term educability, on the other hand, signifies potential for the achievement of competencies. This potential need not, and inevitably will not derive from either the average of or the variation in the development-fostering quality of experience represented in any conceivable sampling of genotypes and

phenotypes to be obtained empirically for the purpose of correlating the IQs of identical and fraternal twins for comparison. Educability depends on the ingenuity of those who try to invent development-fostering experiences through child-rearing procedures and those who set about to improve pedagogic technology for infancy and early childhood. Educability can, on the other hand, be evident in either the rate of developmental achievement or the ultimate level of competence attained in any behavioral domain. No particular measuresof heritability, based upon any given sampling of genotypes and environments or life histories, can possibly yield through subtraction from the total variance of the IQs in any population the ultimate level of achievement attainable through man's ingenuity in the educational domain (see also Hirsch, 1972).

There is yet another reason for the irrelevance of assessments of heritability to educability. Measures of heritability concern the contribution of the variation in genotypes to the variation in any phenotypic characteristic, including intelligence as measured by the IQ. Thus, the emphasis is on what causes variance in the phenotype. Educability is concerned with attaining those abilities, attitudes, kinds of knowledge, kinds of skills, and values demanded by the standards of a culture for a role, a position, or a job. In his first study, where he followed Galton in using twins for determining the relative importance of heredity and environment, E. L. Thorndike (1905) made this statement: "In the actual race of life, which is not to get ahead, but to get ahead of somebody, the chief determining factor is heredity." This notion that life is a race to get ahead of somebody is highly dubious. It reflects the idea of the struggle for existence that emerged from the first studies of human population in relation to the food supply made during the 17th century in the stormy society of pre-revolutionary France. It was formulated most clearly in the famous Essay on the Principles of Population by Parson Thomas Malthus in 1798. It was acknowledged by Darwin as a guiding idea for his Origin of the Species in 1859. It was central to Francis Galton's study of Hereditary Genius in 1869. Galton's work launched the study of individual differences and emphasized the role of heredity in their causation. While it is hard to escape evidences of competition in various aspects of life, one can readily find a political basis for the emphasis on heredity as a defense against the democratization of class privileges by attributing them to nature. While competition surely plays a role in life, the goal of living is much less "to get ahead of somebody" than it is to achieve a respectable and rewarding outlet for one's talents in the scheme of things. It follows that the relevant standard is less one of competition and variance than one of level of achievements required for productive participation in the mainstream of one's culture. Thus, the goal of educability is not to be defined competitively in terms of position in a sample or population, but by the attainment of those abilities, attitudes, kinds of knowledge, kinds of skills and values required for productive and respected participation in the mainstream of one's society. What is important for education, therefore, is not individual differences in achievement reflected in measures of the variance, but rather the achievement of a functional and specifiable level of performance or standard of excellence in performance. Since measures of heritability aim to account for variance in performance or achievement, they are irrelevant for a second reason to the specific functional standards of educational achievement.

The Range of Reaction

Now, do geneticists have anything to say about educability? The answer is: they do indeed. Their answer resides in their concept of the range of reaction authored by Richard Woltereck in 1909 (see Dunn, 1965, p. 95ff). Woltereck was a zoologist who worked with variations in measurable characteristics of pure lines of Daphnia reared under differing conditions of nutrition and temperature. Because a range of reaction is the property of an individual genotype, a major share of work on the range of reaction has been done by botanists. They have had the methodological advantage of plants that clone. Cloning permits the control of heredity because an investigator can have numbers of plants with the same genotype. Samples of plants from the same clone can be reared under differing conditions, and the variations in phenotypic characteristics can be observed and measured. Woltereck's work appears to have stemmed from that of Johannsen (1903, 1909), the Danish botanist and plant physiologist who first distinguished the observable, measurable phenotypes from the inferred genotypes or genetic constitutions. Woltereck's findings, in turn, led him to the concept of the range of reaction. Although educators and psychologists have seldom used it, this concept of the range of reaction is obviously far from new.

By definition, the range of reaction is that variation in any observable, measurable phenotypic characteristic that a given genotype can produce in response to variations in the environment -- or life experience. Botanists typically have investigated the effects of variation in such environmental factors as altitude or chemistry of the soil. In the case of abilities and motives in human beings, what is relevant is not such distal environmental factors as parental income, number of books in a home, and other social-class variables, but rather the intimate, proximate experiences which determine the sequence of adaptive modifications in abilities, motives, understandings, and values as an infant develops, becomes a toddler, acquires language, and then becomes a child. What strategies of investigation does this definition of the range of reaction suggest?

One would consist of rearing monozygotic or identical twins apart. Such studies have been done, but they have usually employed the correlational strategy. One by Holzinger (1929), however, reported the maximal observed difference between pairs of such twins reared apart to be 17 points of IQ. He also reported the correlation of pair differences in IQ with the amount of contrast between the environmental circumstances in the respective homes of the twins being reared apart to be 0.70. According to correlational logic, this finding would suggest that approximately half of the variance ($r^2 = .49$) in the IQs of the sample of identical twins would be attributed to these differences in environmental circumstances.

Even for that pair of twins in Holzinger's sample with a difference in IQ of 17 points, however, only a moderate difference is evident in the development-fostering quality of the experiences in their life histories. The twin version of the investigative strategy suggested by the range of reaction would have one of each pair of identical twins reared in an orphanage such as that in Iowa from which Skeels and Dye (1939) transferred their sample of infants to a ward for moron women or such as that discovered by Dennis (1960) in Tehran where 58% of the infants in their second year were not yet sitting up and 80% of those in their fourth year were not yet walking. The other twin in each pair should be reared through toddlerhood,

according to my methodological fantasy, in the fashion that Myrtle McGraw (1935) reared Johnny. This twin would also have from birth, experiences to foster vocal imitation and later to foster semantic mastery such as we employed with our fifth ward at the Tehran Orphanage (Hunt, Mohandessi, et al., 1976). Thereafter through the first decade, this advantaged twin would be provided with the kind of educational experiences that James Mill and his wife provided for their son, John Stuart. Who knows how much the IQs from pairs of identical twins with such widely differing life histories might differ? For reasons ethical and humanitarian this is but an idle fantasy. It is worth noting in passing, however, that I would expect the genotypes of the various pairs of monozygotic twins to make a substantial contribution to the size of the difference obtained (see Hunt, 1961, p. 323ff).

Since the investigative strategy of deliberately rearing pairs of monozygotic twins apart with markedly differing life histories is out of the question, let me turn to an alternative approach. This alternative consists of comparing the means and standard deviations of such measures of phenotypic competence as the IQ in groups of children from the same population who are reared under differing circumstances. Such an alternative stretches somewhat the definition of the norm or range of reaction, for, to repeat, the norm of reaction is the property of a single individual. The size of the range is a hypothetical distribution of responses to a set of experiential histories unique to each genotype. The alternative strategy suggested consists of taking samples of genotypes from a given population, defined as groups of males and females with equal opportunities for mating. Then samples of infants from such a population are to be reared under differing conditions. The difference between the resulting means of the measures of any phenotypic characteristic is an average of the range of reactions to the differing sets of conditions for the population. When the phenotypic characteristic measured is of a developmental or educational nature, it is directly relevant to educability. Moreover, by improving the development-fostering quality of the experiences induced in groups of children, one can always hope to improve the level of measured achievement and to increase the difference in mean level from that for individuals with development-limiting or development-damaging circumstances. Such differences have the essence of relevance to educability.

Next, I wish to present some illustrative data based on this strategy of investigation. Since there are as yet relatively few data from this strategy of investigation, perhaps you will forgive me for presenting some of my own.

FINDINGS FROM THE STRATEGY SUGGESTED BY THE CONCEPT OF THE RANGE OF REACTION

Orphanage in Tehran

These are outcome findings from our interventions in the child-rearing at the Orphanage of the Queen Farah Pahlavi Charity Society in Tehran (Hunt, Mohandessi Ghodssi & Akiyama, 1976). The purpose of our interventions has been to foster psychological development in the successive samples, or waves, of infant foundlings. In terms of the categories of public-health programs (e.g., those Habich put on the board yesterday), I would call our program a pilot study, despite the fact that its longitudinal nature required a period of eight years. It is merely a demonstration of what <u>can</u> be done. It is not a demonstration of <u>all</u> that can be done by a long shot.

In terms of the new requirement for "informed consent," I do not know how our program would fare. All 66 infants who served as subjects in our program were foundlings. There were no parents or relatives to give consent. Those who actually consented to have them serve as subjects were the authorities of the Queen Farah Pahlavi Charity Society, and my collaborator, Mehri Ghodssi, who directed the orphanage in which all but a few months of our program was conducted. Despite problems with this matter of informed consent, we have not been unmindful of the ethical issues. Because we questioned the ethics of witholding arrangements that might elicit development-fostering experiences, we have not employed contemporary control and experimental groups. Rather, we have used what I like to call "wave design." We started with a control group of 15 infants who were reared according to the customary child-rearing practices of the orphanage. The only intervention consisted of repeated examining with our ordinal scales (Uzgiris & Hunt, 1975). These examinations were made every other week during the first year of the infants' lives, and every fourth week thereafter until they were transferred to another orphanage for toddlers or young children of about three years. The 15 infants in each wave were selected by Mehri Ghodssi, the director, with the counsel of a pediatrician. They were selected from those no more than a month old in the Municipal Orphanage of Tehran and considered to be without pathology. Thus, all the infants do come from at least roughly the same population. Unfortunately, we have no information about the characteristics of either parent.

Now, for the independent variable. Wave I, the controls, consisted of these 15 foundlings who got only the repeated testing common to all waves. Wave II consisted of 10 foundlings who got what was intended to be audio-visual enrichment. It proved to be abortive, however, because the person who was then my resident director failed to keep the equipment operating. I fear we actually did some damage to the infants in this second wave. Wave III also consisted of 10 foundlings These got untutored human enrichment. Instead of providing only a single caretaker for 10 infants, we provided three, but we gave these caretakers no instruction in how to foster development in the infants under their care. They simply did whatever came naturally, and all three were equally responsible for all 10 infants. Wave IV consisted of 20 foundlings. These got the schedule of audio-visual enrichment originally intended for Wave II. The audio portion consisted of tape-recorded music and mother talk. The infants could obtain 15 seconds of this

input at will by moving their arms which were connected with plastic bracelets and strings to switches that turned on the speakers attached to the sides of their cribs. The visual portion consisted of motion in mobiles hung over the cribs which the infants could obtain by jiggling his/her body. There were also other responsive toys provided for these infants. Wave V consisted of 11 foundlings who got tutored human enrichment. The infant caretaker ratio was reduced from 10 to 1 to 3 to 1, or 2 to 1 and the caretakers were taught Badger's (1971a, 1971b) learning programs for infants and toddlers. These programs were supplemented, moreover, with instructions for experiences calculated to foster both vocal imitation and semantic mastery of (ability to name) those parts of the body and items of clothing and actions involved in the caretaking operations. Thus, the independent variable consists of these interventions in the caretaking operations. Each wave followed the preceding by more than a year.

The dependent variables derived from the repeated testing with the scales of Uzgiris and Hunt (1975): (I) Object Permanence, (II) Obtaining Desired Environmental Events, (III-A) Vocal Imitation, (III-B) Gestural Imitation, (IV) Operational Causality, (V) Object Relations in Space, and (VI) Schemes for Relating to Objects. These scales are ordinal in nature in the sense that they consist of sequences of progressively more advanced behavioral organizations elicited by situations arranged in standard fashion. Since they are ordinal in nature, they permit a strategy for assessment that differs from that of the mental age and intelligence quotient. In the testing, the examiners start each infant with steps on each scale on which they succeeded in the preceeding testing. The examiner then proceeds with successive landmarks on each scale until the infant has failed two in succession. Repeated examining with such a longitudinal strategy as we have employed permits one to use the age at which each child first demonstrates achievement of each of the landmarks of behavioral organization on each of the scales.

Those interested in the overall outcome findings from this program of research should consult the paper describing it (Hunt, Mohandessi, Ghodssi & Akiyama, 1976). Here, I shall limit my concern to the mean ages in weeks at which the top steps on these Uzgiris-Hunt scales were achieved by the controls (the infants in Waves I & II), the mean ages at which these same steps were achieved by the foundlings in Wave V who got the tutored human enrichment, and the differences between the means. These appear in Table I.

Table 1 about here

The performances of the foundlings in Wave V differ in two ways from those in Waves I & II. First, whereas all of the 11 infants in Wave V demonstrated achievement of the top step on each scale, substantial portions of those in Waves I and II failed to do so before they were transferred. Thus, only 15 of the 25 managed to demonstrate the retrieval of a desired object that had been hidden in a container after the container had disappeared under three covers by search which reversed the

order in which the container disappeared. Only 10 of the 25 demonstrated genuine imitation of the pronunciation of unfamiliar words. And, for scale VI, only 2 of the 25 spontaneously named an object. Second, even those who demonstrated the critical behavior organizations for the top steps on these scales did so at average ages older than did those of Wave V. In order to make overall age comparisons, I devised an estimate which used the mean age of transfer to another orphanage for the age of achievement of each child who failed to demonstrate achievement of the top steps on these scales. Because these infants had not yet demonstrated these top steps, this is a very conservative estimate on which to base comparisons. Even so, the mean ages at which the infants of Wave V achieved these top steps differ much from the estimated mean ages of their achievement by the controls in Waves I and II. These differences range from a low of 34.2 weeks for the scale of Object Permanence to a high of 86.6 weeks for gestural imitation, and 79 weeks for schemes for relating to objects. The mean of these mean age-differences in weeks is 60.37.

Before I go on with my story, let me note that the top step on the scale of Object Permanence for which we have the smallest difference in mean age of attainment (34.2 weeks) at the Tehran Orphanage is actually the one on which we have the largest obtained difference in mean age when all of the studies we have done are considered (see Hunt, Paraskevopoulos, Schickedanz & Uzgiris, 1975). The largest mean age at which this top step of object permanence has been attained is 184 weeks, and that by children of the Municipal Orphanage in Athens, Greece. The youngest mean age at which this landmark has been attained is 73 weeks, and that by eight consecutive children born to the uneducated parents of poverty served by the Parent and Child Center in Mt. Carmel, Illinois. Thus, the maximum obtained difference in mean ages of attaining top-level object permanence is 111 weeks rather than the 34 weeks obtained in the Tehran Orphanage.

Inasmuch as it is commonly presumed that the development-fostering quality of experience in middle-class homes approximates or at least approaches the optimum (see e.g., Jensen, 1969), it is worth noting that the educational day-care at Mt. Carmel enabled these eight consecutive infants born to the uneducated parents from the poverty sector served by the Parent and Child Center to attain top-level Object Permanence at a mean age (73 weeks) 25 weeks younger than that (98.31 weeks) for 12 home-reared infants from predominantly professional families in Worcester, Massachusetts without such an intervention. Thus, these infants of unskilled and often unemployed parents had experience in their educational day care that served to advance their attainment of top-level Object Permanence ahead of that by infants from predominantly professional families by nearly half a year (25 weeks).

A digression concerning the nature of the experience that seems to have produced this advance may be of interest. The educational day-care at Mt. Carmel was based upon Badger's (1971a, 1971b) training programs for infants and toddlers. The mothers who served as teachers' caretakers at the Parent and Child Center had been taught by Badger to arrange situations for their infant pupils to keep them interested rather than either bored or distressed by overmatching. In retrospect, the surprising advancement in object permanence appears to have been a serendipitous outcome of experience with a shape box. During a visit when this educational day-care was being initiated, Earladeen Badger and I found the infants in cribs along the wall as are typically seen in orphanages. We looked at each other with dismay. When we noted that the floor was well carpeted, I suggested, "Let's get them on the floor." In a search for something of interest, I happened to select the shape box.

The infant of about six months whom I was tending could not manage to hold the round block sufficiently vertical to get it through the round hole in the top of the box. It seemed to me that he might be able to manage a ping-pong ball, so we got one. At first, I helped him hold it over the round hole. It disappeared, making a noise as it hit the bottom of the box. Then I helped the infant use his left hand to lift the hinged top. When he saw the ping-pong ball, he went for it immediately, and with several such repetitions, he learned to lift the top and retrieve the ball on his own. Thereafter it became his preoccupation, and he persisted long after I ceased to be interested. Neither Earladeen Badger nor I thought much of this incident until after the bi-weekly testing had uncovered a surprisingly rapid development of object permanence. Then, during one of her regular teaching visits, the caretakers remarked on the interest of the infants in the shape box. With the increasing complexity of the task afforded by round holes, square holes, rectangular holes, and triangular holes with blocks of corresponding shapes, these boxes proved a favorite preoccupation of these infants from the time they could sit up at about 26 weeks of age to their attainment of top-level object permanence at 73 weeks.

After the fact, it is easy to see that the experience provided by this shape box could readily foster object construction. From the ping pong ball to the cylindrical block to the square block to the rectangular block, etc., their disappearance through the appropriate hole in the top of the box makes a noise. The child can then act to lift the hinged-top box. This act enables him to see again the block that has disappeared. Insofar as this generalizes, and it certainly generalized from play with the shape box to the regular testing situations and to other testing situations in which a desired object was made to disappear into a little chalk box which, in turn, was made to disappear through a door or in a series of tall wastebaskets, it constitutes the object construction manifest in the critical actions on our scale of Object Permanence.

Now let us return to the significance of these differences in mean ages of attaining the top steps on our sensorimotor scales. What does it mean to say that the maximal obtained difference in mean age of attaining the top step on the scale of object permanence is 111 weeks, more than two years, or approximately 26 months? How large is this? Since we have no ready-made frame of reference for answering such a question, it is useful for communication purposes to transform this difference in mean ages to one of difference in points of the IQ-ratio for object construction. In order to do this, we use as the norm, or mental age, the mean age at which those home-reared children without intervention attained top-level object permanence without intervention of any kind in their rearing. The mean age of this attainment for such children as we have tested in Athens, Greece, and Worcester, Massachusetts, rounds to 110 weeks. If one divides this mental-age equivalent of 110 weeks for object permanence by the mean chronological age of 73 weeks at which top-level Object Permanence was attained by those infants from uneducated families of poverty who received educational day-care at Mt. Carmel, and then multiplies by 100, one obtains a mean IQ-ratio of 150. When one also divides this mental age of 110 weeks by 184 weeks, the mean age of attainment for the children of the Municipal Orphanage in Athens, their IQ-ratio for object construction averages approximately 60. Now, by subtracting the latter from the former, one obtains a maximal obtained difference (150 - 60 = 90) of 90 points in IQ-ratio for this branch of sensorimotor development. Since the children at the Municipal

Orphanage in Athens do not come from the same population as do the eight offspring of the uneducated and unskilled parents served by the Parent and Child Center of Mt. Carmel, this difference fails technically to fulfill the definitional requirements for the range of reaction. On the other hand, it is hard to see why one should expect the genotypic potential for object construction in these children from the bottom of the socio-economic-educational scale in Mt. Carmel to be any greater than that of the progeny of largely illegitimate children from parents of working class background in Athens, Greece.

Since it is common to believe thatthe quality of development-fostering experience provided by educated families of the middle-class approaches the optimum, it is of interest to compare the estimated mean IQ-ratios for object construction in the Mt. Carmel children with that of the Worcester children. Since the IQ ratio for the former is 150 and that of the latter is 112 (110 + 98), the educational day-care at Mt. Carmel appears to have advanced the rate of object construction in these offspring of uneducated parents of poverty served by the Parent and Child Center at Mt. Carmel by 38 points of IQ-ratio ahead of that for the home-reared offspring of predominantly professional families in Worcester.

Now look again at Table 1 and this time at the IQ-ratios derived from the differences in mean ages of attaining the top steps on our ordinal scales. These range from 32 points for the scale of Object Permanence to 83 points for the scale of Gestural Imitation. The foundlings in Wave V show an average superiority of 46 points of IQ-ratio over the controls (Waves I and II) for all seven scales.

These transformations have been made only to enable you to use a familiar frame of reference in getting a sense of how much variations in experience can modify the average rate of development in groups of infants. These IQ-ratios indicate only variations in average rates of achievement from past experience in groups of infants. Such performances of the infants on our ordinal scales are useful for determining the kinds of experience which are development-fostering. Knowledge of what fosters and what does not is necessary for developing a pedagogy for infancy and early childhood. On the other hand, these IQ-ratios should not be considered to have implications for the rate of future achievement nor for the ultimate level of the competence to be achieved. While it appears to become progressively more difficult to make up deficiencies of achievement as the years pass, future development depends upon the pedagogic or development-fostering quality of the experience to be elicited by those circumstances these children will encounter in their lives.

Variations in Language and Personality Achievement: Tehran

Now consider the variations in personality and language achievement associated with the interventions in the child-rearing at the orphanage in Tehran. For these we have no metrics to manipulate.

Perhaps I should make clear that I did not start this program in Tehran in order to study the development of language and personality. As a matter of fact, I started it in order to test some of my notions about intrinsic motivation (see Hunt, 1960, 1963a, 1963b, 1965, 1966a, 1966b). The significance of the program for language development emerged gradually. The most relevant comparisons are those among the controls (Waves I & II combined), Wave III, with untutored human

enrichment, and Wave V with tutored human enrichment. It is the dramatic influence of the deliberate effort to foster vocal imitation and semantic mastery by what we taught the caretakers of the infants in Wave V that is most significant for theory of language development. The experiences provided by these caretakers whom we taught also produced personalities in Wave V which were markedly more lively and attractive than those in Waves I and II.

In the controls (Waves I & II), both expressive and receptive language were essentially absent even as late as three years of age. The absence of expressive language was evident from two facts. First, these children almost never vocalized unless they were in distress. Then they cried. They did not, with the exception of two that had been special pets of a caretaker, use vocal means to obtain their desires in their interaction with either caretakers or each other. Second, only the two who had been pets ever spontaneously named an object in the examining situation.

My evidence for saying that receptive language was also essentially absent at three years is somewhat less solid. It is based on what I like to call "horseback research." During one of my visits when these children were in the latter part of their third year, I would stand before them in the playroom and ask one of their familiar caretakers or examiners to tell a child to "go to the man." I would stand there passively while looking at the target child with an expression intended to show interest. Only the two who had been pets ever moved toward me in this crude test of receptive language. On the other hand, if I pointed to one of the children and extended my arms in inviting fashion, the child would either come running or his/her face would cloud up in fear as he/she withdrew further. Either way, all seemed to respond with understanding to the gesture, but not to spoken language. In another such crude test, I would place a piece of paper on the floor beside one of the low tables and request one of the familiar examiners or caretakers to tell an infant to " put the paper on the table." Again, they failed to respond. On the other hand, if I could get one of these children to come to me by gesturing, I could then point to the paper, point to the table, then make a motion from the paper to the table. By repeating this sequence two or three times, I could get about half of those who would come to me to pick up the paper and put it on the table.

From the standpoint of the theory of language, I am inclined to believe that what Noam Chomsky (1965, 1969) has termed "deep structure," consists of a cognitive understanding of a situation and of the action in that situation. I believe it is this cognitive understanding that language symbolized. I believe also that both phonemics and semantics come before syntax. These children of Waves I and II show a cognitive understanding of what can be symbolized through gesture, but they have essentially no semantic mastery of these cognitions, almost no understanding of language symbols.

Next, consider the language behavior of the children in Wave V. All 11 of them had spontaneously named a familiar object in the testing situation before age two, and several of them at ages very much younger. Their average age of achieving this top landmark on the scale of schemes for relating to objects was 90 weeks. I can best dramatize this contrast by relating some of the experiences with these children in Wave V when I first saw them.

When I arrived for my planning visit in October of 1974, it was the Shah's birthday. The next day was his son's birthday, so I had to twiddle my thumbs for two days before I could see these youngsters whose performances I had been following through monthly reports. When I finally got to the orphanage, the customary tea ceremony was prolonged inordinately. When the principle examiner finally came for me, she took me to the door of a playroom in which the pairs or triads of infants were arranged in a semi-circle in front of their respective caretakers. As I entered the room, a signal was given, and in unison, they called out "Hallo." Then I learned why the prolonged tea ceremony. They had been trying to get these children to say in unison: "Hello, Dr. Hunt." That turned out to be too much, so they settled for "hello." Even this was a marvelous contrast to what I had seen of those in earlier waves.

Immediately after the greeting, Cambiz came to me requesting in both language (Farsi, the language of Iran) and gesture, to be picked up. He resisted being put down when I was invited to see the new examining room, so I carried him along. Through a window opposite the door through which we entered the examining room, there was a lawn sprayer. Cambiz saw it immediately and began to cry out with enthusiasm: "Ab, ab, ab." Now Ab is the Farsi word for water, Cambiz was naming spontaneously with a vengeance at age 23 months. I had been told that Cambiz was very good at imitating, so, impulsively, I thought I would teach him to say "water." I called his name, and immediately said, "Water." Cambiz paid little attention to me. Instead, his left arm was reaching toward the sprayer as he continued to say: "Ab, ab, ab." After several such efforts on my part demonstrated that I would be unable to get him into the imitation game so long as he was excitedly viewing the sprayer, I carried him back into the hall out of the sight of the sprayer. Then, I repeated, "Cambiz, water!" Cambiz looked at me and replied, "awter." He omitted in his imitation the sound of theinitial consonant symbolized by the letter w. Yet, in less than a dozen presentations, he said the word, water, as plainly as I did and with almost the same intonation. On another day, my glasses intrigued Cambiz. He quickly picked them off my face while saying, "Enack, enack, enack." Again, spontaneous naming. He also attempted to put my glasses on his own face. Impulsively, again, I thought of teaching him to say the English word, "glasses." Again, it was impossible to get him into the imitation game so long as he was preoccupied with manipulating and naming "enack." Putting my glasses into their case and the case out of sight in my pocket was to no avail. Cambiz quickly demonstrated object permanence by searching under my jacket for the glasses case, all the while saying, "enack, enack, enack." It was necessary to give my glasses to someone else and to move out of the sight of the person holding them in order to get Cambiz interested in the imitation game. I would say, "Cambiz, glasses!" At first, Cambiz responded with, "asses." When I slowed my vocalization of the word, glasses, on the second and third presentations, Cambiz responded with, "lasses." I uttered the double consonant combination of gl, "Gl, gl, gl, glasses," with the consonant combination followed by a prolongation of the long a sound and then the ses. Cambiz responded, "Glaaases." After this, I could shorten the duration of the aaa, and Cambiz said the word glasses as clearly as I had said it. At this point, I was told thatsuch a consonant combination as gl does not exist in Farsi, and that it is especially difficult for Persians to combine two consonants without a vowel between them. Cambiz managed to utter a match for my model with no more than a dozen presentations.

Now an experience with Shabnam, a little girl in her eighteenth month. I was holding her, while the chief examiner was showing me that she could imitate the names of all the children in the group. Although my Farsi is almost nil, Shabnam's imitative responses matched the sounds modeled by the examiner perfectly to my ear. Finally, the examiner came to Yass. Because Yass had been adopted the week before I arrived, I never saw her. When the examiner said, "Yass," Shabnam's manner changed abruptly. She dropped theimitation game, twisted her body in my arms and reached her arm out toward the door behind me and said, "Yass rafteh." This is theFarsi equivalent of "Yass gone." It is a sentence. Moreover, it reflected an actual state of affairs of which Shabnam showed full cognizance.

Shabnam had never been taught to say a sentence. Her caretaker had done her best to keep the infants in her charge interested and she was said to have followed instructions for fostering vocal imitation and semantic mastery. In order to foster vocal imitation, the caretakers were taught to imitate the spontaneous vocalizations of the infants in their care in order to get vocal games going. Thus, they imitated first the cooing sounds, and then the babbling sounds. When an infant had mastered several babbling patterns, the caretaker introduced into the imitation game a procedure of "follow-the-leader." In this procedure, the caretaker got a vocal game going with one of the familiar babbling patterns, shifted to another, and then as the child followed, the examiner shifted to yet another. Once the infants in her care had achieved skill at following the leader, the caretaker was to introduce new phonemic combinations that she had not yet heard the infant make. This led to genuine imitation through which she could increase the phonemic repertoire of the infants in her charge.

The procedure for fostering semantic mastery consisted chiefly of sharpening up the bases for association of heard words with concrete experiences. The caretakers were urged to talk about caretaking activities as they conducted them. The illustrative paradigm involved ear-washing. The caretaker was to say: "Now I'm going to wash your ear." As her vocal emphasis hit the word ear, she was instructed to have the washcloth make contact with the anatomical ear. Such procedures were to be used throughout the caretaking operations.

Since I observed just these procedures in operation after operation, I am confident that these children had very little or no tutelage in sentence structure, yet, when Shabnam heard the examiner say the name, Yass, it prompted her to leave the imitation game, and to symbolize in language her understanding that Yass was no longer in their midst. Even though this sentence demonstrated the top level of Object Relations in Space, it was several months before Shabnam was credited with this achievement because the action illustrated in our teaching cinema consisted of indicating the whereabouts of familiar but absent persons rather than indicating merely their absence.

As the examiner was showing me that Shabnam could imitate the names of her features and the parts of her body, etc., she pointed to the various parts of her body and the various pieces of clothing that she was wearing. Because the examiner's English was shallow and I have almost no command of Farsi, we had some difficulty in communication. Finally, I asked how to say: "What is it?" What I heard can be transliterated as three syllables: "In chi aay?" When I gently pulled

Shabnam's hair and asked, "In chi aay?" she replied, "muh." The examiner nodded, for muh is the Farsi word for hair. In this fashion, I learned that Shabnam, at less than 18 months of age, had a vocabulary of the order of 50 words. In the course of a few days, I was able to demonstrate in similar fashion that all 10 of the remaining 11 knew the names not only of the parts of their bodies, but the names for the pieces of clothing they wore, the foods they ate, and also for a good many of the actions involved in caretaking.

A few days later, I found the caretaker of Monee picking up the rings of the stacking toy. As she picked up each ring, she named its color for Monee to imitate. I wondered immediately if Monee was developing semantic mastery of colors. After learning how to ask in Farsi, "What color is it?", I proceeded to hand Monee each of the rings on the stacking toy as I asked the question, "What color is it?" Monee responded correctly with the names for red, yellow, green, and blue. I wondered if these were merely names for these concrete rings, or if Monee had achieved semantic mastery of the elementary abstraction of colors. So, I proceeded to carry him to the hall where there were pictures on the walls. There I pointed to spots in thepictures and asked, "What color is that?" Monee responded correctly for these four primaries repeatedly. He had clearly achieved semantic mastery for color. Cambiz and Parviz also named colors, but not correctly with such consistency as Monee. When one considers that only about a fourth of the four-year-olds participating in Head Start classes show such expressive semantic mastery for colors (Kirk,Hunt & Lieberman, 1975), semantic mastery of such an elementary abstraction at the age of two years may be seen as no mean achievement, and especially in orphanage reared-infants.

Although we have no nice quantification of the degree in which the language achievements of the controls (WavesI & II) differ from those of the infants in Wave V, it is obviously tremendous. It is also worth noting that at about age two, the children of Wave V were in language skills also the equal of or superior to those in Wave III who got untutored human enrichment. These facts suggest that what we taught the caretakers to do in order to foster vocal imitation and semantic mastery provided important experiences for language achievement.

Personality: Mood, Initiative and Social Attractiveness

These experiences that we taught the caretakers of the children in Wave V to provide also had a marked influence on the personalities of the infants in their charge as shown in the mood implied by their facial expressions, their initiative and enthusiasm, in fact, their all around social attractiveness. Comparing the facial expressions and the gestures in pictures of some of the control infants (Waves I & II) with some of those of Wave V helps to bring out the contrast. A sample of four of the former over a sample of four of the latter appears in Figure 1.

Figure 1 about here

These pictures were originally taken on the wards, in color, merely to enable me to recall the individual children. They were taken with fast film to avoid the irritating shock of a flash. They were also taken in each case after I had been around the orphanage for considerable time and was becoming a familiar figure. The expressions of the infants in the upper four pictures in Figure I are typical for children in Waves I and II. Evidence of the proverbial exhuberance of toddlerhood is clearly absent. Their facial expressions are glum, and these expressions went with a marked lack of initiative and activity that betokens apathy. These children appeared to expect nothing and to seek nothing. It is difficult to see these children of Waves I and II as individuals. Their names would not stick with me.

Consider the lower four pictures in Figure 1. The first one on the left shows Cambiz in the arms of his caretaker hitting a ball that hangs on a string attached to a ring in the ceiling. His exhuberant enthusiasm for this enterprise is evident. The second shows Shabnam in the arms of her caretaker. Her outgoing manner is evident in the gesture of waving. The third shows Parviz busy with the rings of his stacking toy. The fourth shows Monee with arm extended and a facial expression that demands something of the adult standing beside him.

These children show motivational initiative. They expect and demand notice and aid from adults they encounter. They are anything but apathetic and their expressions, gestures, and actions express joy of life. Moreover, they are socially attractive. This is a judgment validated by the fact that seven of the eleven in Wave V were adopted by families characterized by the chief examiner as "very high people." Of the 55 children involved in the four earlier waves, only two were ever adopted, and they were adopted when they were a little less than 6 months old because they were pretty babies. Seven of these 11 were adopted because they were attractive two-year-olds.

It would appear that the experiences involved in the vocal games prescribed to foster vocal imitation as a means of achieving a phonemic repertoire also had an important influence on facial expression, motivational initiative, social expectations, and social attractiveness. These effects may well have derived from the fact that participation in the vocal games enabled the utterances of the child to elicit responses from their caretakers. Uncontrolled, however, is the fact that in Wave V, each child had a continuing relationship with a caretaker whereas in Wave III, all three of the caretakers were equally responsible for all 10 infants. Whatever the details of the causation, the contrast in motivational initiative and social attractiveness appears to be as great as that in language achievement, but again, we have no metric with which to quantify it. The largest obtained difference in a quantified dimension of development at the Tehran Orphanage is that in the mean age of achieving top level gestural imitation. This is a difference in mean ages of attainment of 86.6 weeks, which in mean IQ-ratios is of the order of 83 points. Recall that the largest obtained difference in mean age of attaining top-level Object Permanence was 11 weeks or nearly 26 months which transforms into a difference in mean IQ-ratio of the order of 90 points. These contrasts in language achievement and facial expression and motivational initiative are unquantified, but I believe you will agree that they are also impressive.

Other Data

These data from my own research are limited to the first three years of life. Let us turn to other data from this strategy of investigation for somewhat older children. One set comes from a study by Wayne Dennis (1966) in which he summarized the results obtained from giving the Goodenough Draw-A-Man test to samples of typical children, aged between 6 and 13 years, whose experiential histories were those of typical families in some 50 cultures over the world. Since this study is cross-cultural, the children do not come from the same population, so the data do not fulfill the definitional requirement of a range of reaction. Nevertheless, giving the paucity of data from this strategy, they are suggestive.

The highest mean Draw-A-Man IQ was 125, and it came from a sample of middle-class American children. Mean Draw-A-Man IQs of 124 and 123 were obtained for Japanese children of Kyoto and mean IQs almost as high for poor children from a Japanese fishing village. A mean Draw-A-Man IQ of 115 was also found for Navajo Indian children. At the lower end of the range was a mean Draw-A-Man IQ of 53 for a sample of nomadic Shilluk children of the Sudan, and a mean IQ of 56 for the children of nomadic Bedouins of Syria. If one subtracts 53 from 125, the maximal obtained difference in Draw-A-Man IQ for children from 6 to 13 years of age is 72 points. Even though population is not controlled, this is a difference clearly associated with amount of meaningful experience with representative graphic art. A difference of 72 points in older children clearly shows that what was originally presumed by Goodenough (1926) to be culture free is far from it.

Other evidence can be obtained from combining the results from different studies. First, the damage from orphanage rearing appears to be of the order of 50 IQ points. This statement is based upon the evidence in Dennis' (1973) Children of the Creche and in Skeels' (1966) follow-up study comparing the IQs of children who remained in orphanages with those of children who were transferred from the Iowa orphanage to the ward of moron women in an institution for the mentally deficient, and then later adopted. Secondly, educational day-care has been found to increase the IQ substantially. In their Milwaukee study, Heber, Garber, et al. (1972) started with 40 Black mothers with IQs of 75 or below. The 20 infants in the treated group got home visits during their first six months, and thereafter were taken five days a week to a center where each child had a tutor. The tutors were provided with curricula designed to foster cognitive development and language skills. The infants of the other 20 mothers were reared at home. Home visitors maintained contact with the untreated families, counseled the mothers in home management, but not in child-rearing. The treated and untreated children got the same schedule of repeated testing. At 66 months of age, the IQs of the treated group averaged 124 while those of theuntreated group averaged 94. Thus, the effect of the treatment would appear to be of the order of 30 points, but let us take only the 24 points of advance of the treated group above the norm of 100. If we then add the 50 IQ points of damage from orphanage rearing to these 24 points advance from educational day-care, one obtains a maximal obtained difference of 74 IQ points. Such evidence suggests that the effects of experience on the IQ can be of the order of 75 points. Heber (1976) has now followed the school progress of these children for 6 years. Once their development became entirely dependent upon the development-fostering quality of the experiences afforded by their homes

and standard schooling, the average IQ of the treated group dropped from 124 to 109. At the same time, those of the untreated group dropped from 94 to the upper 70s. Thus, while both groups lost IQ points, the treated group maintained their 30 points of superiority over those in theuntreated group. The loss in mean IQ of all the Black children that followed the termination of educational day-care illustrates the fact that plasticity can cut both ways.

Another source of evidence has been adoption studies. One by Scarr and Weinberg (1976) has indicated that most if not all of the inferiority of black and interracial children in IQ is a function of rearing conditions. Their study compared the IQs of Black and interracial children adopted by white parents in 101 Minnesota families with the IQs of Black children reared in their biological families in the population. Adopted children under four years of age were excluded because the IQs of children under four are considered to be less predictive than those of older children. The educational level of the biological parents was used to estimate the level of their ability; it corresponded to the educational median "for that age cohort of the population." The educational level of the adoptive parents, however, was much above average as was also their occupational status and income. Whereas the mean IQ of Black children reared in their own homes in the North Central Region is only 90, the mean IQ of the Black adoptees was 106. Thus, the mean for the Black children adopted into white homes is a full standard deviation above the mean IQ of Black children of the North Central Region. Moreover, those Black children adopted during their first yead had a mean IQ of 111 as compared with a mean of 97.5 for those who were adopted later. Thus, for such early adoption, the gain was of the order of 20 IQ points or 1.33 standard deviations. These gains were obtained with the customary rearing practices of educated, middle-class white parents and without any of the special pedagogic expertise that appears to be developing (see Hunt, 1979). The conclusion of the Scarr-Weinberg study has been called into question because Black adults as well as children of mixed parentage might be expected to average higher in IQ than Black children of the whole North Central Region. It is, however, extremely unlikely that they would average as high as 100. So, even if this contention be true, it would merely reduce the size of the average gains from adoption. The mere fact of a continued gain reinforces other evidence showing that gains obtained in the first three years can be sustained well beyond three years with continued experience of high development-fostering quality. Moreover, it shows that a major share of the large gains obtainable during the first three years can be sustained with continued experience of high development-fostering quality well beyond the sensorimotor period.

Another adoption study (Schiff, et al., 1978) indicates that a major share of the observed inferiority of IQ and of school failure to be found in the children of working-class parents is a function of their life experience. Schiff, et al., examined the files of all of the children who had been abandoned at birth between 1962 and 1968 in the files of six public agencies from various parts of France. They focused their attention on cases where the absence of professional qualification was known for both parents. In a fifth of these case (n = 32) the children had been adopted before the age of six months into a family of high socio-professional status. They were able to locate all 32 of these children and

to obtain both IQ scores and school records for them. Moreover, for 28 of these 32 children from biological parents belonging among the bottom third in socio-professional status, they were able to find the biological mother. Among these 28 biological mothers, 20 turned out to have children of school age who had not been abandoned. They obtained school records for all 39 of the biological children of these 20 mothers and IQ tests from one biological child of each. IQ scores, moreover, were obtained "for most of the subjects" by administering the full WISC as well as a French collective test (ECNI). The IQs of the 32 adopted children averaged 108.7 (S. D. = 10.7) as compared with an average of 94.9 (S. D. = 11.3) for the 20 biological children, a difference of approximately one norm-based standard deviation. This difference is based entirely on scores from the French collective test (ECNI). When Schiff, et al., compared the observed rate of school failure for the adopted children (18%, S. D. = 9%), they found it to be compatible with the rate expected solely from the social status of the adoptive parents (23%), but very much below the rate expected from the social status of the biological parents (69%). Similarly, for psychometric failure, defined as the IQ on the ECNI for which national statistics have shown an academic failure of 55% at the end of primary school, theobserved percentage of adopted children who failed this criterion (39%, S. D. = 9%), was considered "compatible with that expected on the basis of the social status of the adoptive parents (30%), but it is very different from that expected on the basis of the biological parents (69%)." In nice agreement with my message, Schiff, et al., conclude that "our results bring no information about estimates of the 'heritability' of IQ scores, but they do underline the fallacy of using such estimates to 'explain' scholastic and intellectual failures of working-class children."

CONCLUSION

Nothing I have said here should be taken as an intention to deny the existence of individual genetic differences. On the other hand, this evidence does show that the cumulative effects of experience thatindividual children have with their physical and social circumstances in the course of their life histories makes a very substantial difference in the intellectual and social competence they achieve at various ages up to 9 years. From such evidence, I am inclined to believe that all children born without pathology have the genotypic potential to acquire all the knowledge, motivation, skills, and values required to participate productively in the mainstream of any society in this world if their potential is realized through appropriate experiences. This is not to say that any infant can be made into an intellectual giant, an outstanding concert pianist, or a great world-class athlete. For productive participation in the mainstream, no society demands such specialized excellency of achievement. Yet, if we take seriously our value of equality of opportunity, even such limited evidence as we now have demands that the welfare of the children of the future should not be endangered by social policies based on the indirect and irrelevant assessments of educability obtained by subtracting indices of the percentage of heritable variance in the IQ from 100. It is a shame that we have so few data from the more direct strategy of investigation suggested by the concept of the range of reaction. It is high time that we undertook to make moreuse of this strategy of investigation in order to test hypotheses about how to arrange situations to match the existing achievements of children so as to fealize more of their developmental potential. Such research promises to lead to a pedagogy for infancy and early childhood with genuine power. Although I feel strongly that

society should deny no man the right to conduct investigations as he wishes (limited only by the rights of subjects), I believe that our value of equality of opportunity now demands that special preference should be given by foundations and federal agencies to support for research concerned with educability that employs this direct strategy for its assessment suggested by the concept of the range of reaction.

Thank you very much.

References

Badger, E. 1971a. Teaching Guide: Infant Learning Program. Paoli, Pa.: The Instructo Corporation.

Badger, E. 1971b. Teaching Guide: Toddler Learning Program. Paoli, Pa.: The Instructo Corporation.

Beadle, G. W. 1945. Biochemical genetics. Chemical Review, 37, 15-96.

Bloom, B. S. 1964. Stability and change in human characteristics. New York: Wiley & Sons, Inc.

Chomsky, N. 1965. Aspects of the theory of language. Cambridge, Mass.: MIT Press.

Chomsky, N. 1969. Deep structure, surface structure, and semantic interpretation. Bloomington, Ind.: Reproduced by the Indiana University Linguistics Club.

Cicarelli, V. G., et al. 1969. The impact of Head Start: An evaluation of the effects of Head Start on children's cognitive and affective development (2 vols.) Bladensburg, Md.: Westinghouse Learning Corporation.

Dennis, W. 1960. Causes of retardation among institutional children: Iran. Journal of Genetic Psychology, 96, 47-59.

Dennis, W. 1966. Goodenough scores, art experience, and modernization. Journal of Social Psychology, 68, 211-228.

Dennis, W. 1973. Children of the Creche. New York: Appleton-Century-Crofts.

Dunn, L. C. 1965. A Short history of genetics. New York: McGraw-Hill.

Epstein, H. T. 1974a. Phrenoblysis: Special brain and mind growth periods. I. Human brain and skull development. Developmental Psychobiology, 7 (3), 207-216.

Epstein, H. T. 1974b. Phrenoblysis: Special brain and mind growth periods. II. Human mental development. Developmental Psychobiology, 7 (3), 217-224.

Erlenmeyer-Kimling, L. & Jarvik, L. F. 1963. Genetics and intelligence: A review. Science, 142, 1477-1479.

Fisher, R. A. 1918. The correlation between relatives on the supposition of Mendelian inheritance. Transactions of the Royal Society, Edinburgh, 52, 399-433.

Galton, F. 1869. Hereditary genius: An inquiry into its laws and consequences. London: Macmillan.

Gesell, A. 1954. The ontogenesis of infant behavior. In L. Carmichael (Ed.), Manual of child psychology. New York: Wiley. Ch. 6.

Goodenough, F. L. 1926. The measurement of intelligence by drawings. Yonkers-on Hudson, N. Y.: The World Book Co.

Hebb, D. O. 1949. The organization of behavior. New York: Wiley.

Heber, R. 1976. Research in prevention of socio-cultural mental retardation. Paper presented at the Vermont Conference on the Primary Prevention of Psychopathology. To appear in: D. G. Forgays (Ed.), Vol. II, Environmental Influences. Proceedings of the 1976 Vermont Conference on the Primary Prevention of Psychopathology, Burlington, Vt.: University of Vermont.

Heber, R., Garber, H., Harrington, S., Hoffman, C., & Falender, C. 1972. Rehabilitation of families at risk for mental retardation. Madison: Rehabilitation Research and Training Center in Mental Retardation. University of Wisconsin.

Herrnstein, R. 1971. I. Q. The Atlantic Monthly (September), 228, 43-64.

Herrnstein, R. 1973. IQ in the meritocracy. Boston: Little, Brown & Co.

Hirsch, J. 1970. Behavior-genetic analysis and its biosocial consequences. Seminars in Psychiatry, 2 (1), 89-105.

Hofstadter, R. 1945. Social Darwinism in American thought. Philadelphia: University of Pennsylvania Press.

Holzinger, K. J. 1929. The relative effect of nature and nurture influences on twin differences. Journal of Educational Psychology, 20, 241-248.

Hunt, J. McV. 1960. Experience and the development of motivation: Some reinterpretations. Child Development, 31, 489-504.

Hunt, J. McV. 1961. Intelligence and experience. New York: Ronald Press.

Hunt, J. McV. 1963a. Motivation inherent in information processing and action. In O. J. Harvey (Ed.), Motivationand social interaction: The cognitive determinants. New York: RonaldPress. Pp. 35-94.

Hunt, J. McV. 1963b. Piaget's observations as a source of hypotheses concerning motivation. Merrill-Palmer Quarterly, 9, 263-275.

Hunt, J. McV. 1965. Intrinsic motivation and its role in psychological development. In D. Levine, (Ed.), Nebraska Symposium on Motivation, 13, 189-282. Lincoln: University of Nebraska Press.

Hunt, J. McV. 1966a. Toward a theory of guided learning in development. In R. H. Ojemann & Karen Pritchett (Eds.), Giving emphasis to guided learning. Cleveland, O.: Educational Research Council, Pp. 98-160.

Hunt, J. McV. 1966b. The epigenesis of intrinsic motivation and early cognitive learning. In R. N. Haber (Ed.), Current research in motivation. New York: Holt, Rinehart & Winston, Pp. 355-370.

Hunt, J. McV., Mohandessi, K., Ghodssi, M. & Akiyama, M. 1976. The psychological development of orphanage-reared infants: Interventions with outcomes (Tehran). Genetic Psychology Monographs, 94, 177-226.

Hunt, J. McV., Paraskevopoulos, J., Schickedanz, D., & Uzgiris, I. C. 1975. Variations in the mean ages of achieving object permanence under diverse conditions of rearing. In B. L. Friedlander, G. M. Sterritt & G. E. Kirk, (Eds.), The exceptional infant (Vol. 3): Assessment and intervention. New York: Brunner/Mazel, Pp. 247-262.

Jencks, C. 1972. Inequality: A reassessment of the effect of family and schooling in America. New York: Basic Books.

Jensen, A. R. 1967. Estimation of the limits of heritability of traits by comparison of monozygotic and dizygotic twins. Proceedings of the National Academy of Science, 58, 149-157.

Jensen, A. R. 1969. How much can we boost IQ and scholastic achievement? Harvard Educational Review, 39, 1-123.

Jensen, A. R. 1972. Genetics and education. New York: Harper and Row.

Jensen, A. R. 1973. Educability and group differences. New York: Harper and Row.

Johannsen, W. 1903. Om Arvelighed i Samfund og i rene Linier. Oversigt over det Kgl. danske videnskabernes selskabs forhandlinger #3 forelagt i modet den 6 Feb. 1903. (From Peters, J. A., Classic Papers in Genetics. Englewood Cliffs, N. J.: Prentice Hall, 1959).

Johannsen, W. 1909. Elemente der exakten Erblichkeitslehre. Jena: Fischer. (From Dunn, 1965).

Kirk, G. E., Hunt, J. McV., & Lieberman, C. 1975. Social class and preschool language skill: II. Semantic mastery of color information. Genetic Psychology Monographs, 91, 299-316.

Loevinger, J. 1943. On the proportional contributions of differences in nature and nurture to differences in intelligence. Psychological Bulletin, 40, 725-726.

McGraw, M. B. 1935. Growth: A study of Johnny and Jimmy. New York: Appleton-Century.

McGuire, T. R., & Hirsch, J. 1977. General intelligence (g) and heritability (H^2, h^2). In I. C. Uzgiris and F. Weizmann (Eds.), The structuring of experience. New York: Plenum Press.

Payne, J. S., Mercer, C. D., Payne, R. A., & Davison, R. G. 1973. Head Start: A tragicomedy with epilogue. New York: Behavioral Publications.

Scarr, S., & Weinberg, R. A. 1976. IQ test performance of Black children adopted by White families. American Psychologist, 31, 726-739.

Schiff, M., Duyme, M., Dumaret, A., Tomkiewicz, S. & Feingold, J. 1978. IQ and school failures of working-class children adopted early into upper-middle-class families. (Mimeographed manuscript as submitted to Science.)

Skeels, H. M. 1966. Adult status of children with contrasting early life experiences. Monographs of the Society for Research in Child Development, 31 (3), Serial No. 105, 1-65.

Skeels, H. M., & Dye, H. B. 1939. A study of the effects of differential stimulation of mentally retarded children. Proceedings of the American Association on Mental Deficiency, 44, 114-136.

Steiner, G. 1976. The children's cause. Washington, D. C.: The Brookings Institute.

Thorndike, E. L. 1905. The measurement of twins. Archives of Philosophy, Psychology, and Science Method, 1, 1-64.

Uzgiris, I. C., & Hunt, J. McV. 1975. Assessment in infancy: Ordinal scales of psychological development. Urbana: University of Illinois Press.

Watson, J. D., & Crick, F. H. C. 1953. A structure for deoxyribose nucleic acid. Nature, 171, 737 & 964.

Table 1

Mean Ages in Weeks of Achieving Top Steps on Uzgiris-Hunt Scales by Waves I, II and Wave V with the Differences Between Them

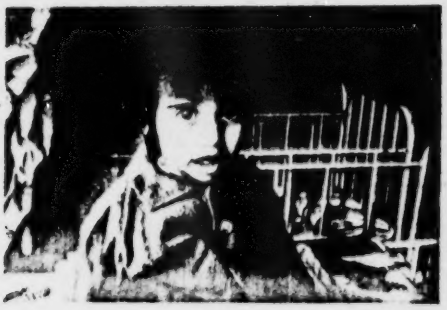
	I & II		V		Difference	
Scales	N[a]	Estimated[b] Mean Age	N	Mean Age	in Mean Age	in IQ-Ratio
I. Object Permanence	15	127.2	11	93.0	34.2	32
II. Development of Means	12	148.2	11	94.0	54.2	41
III-A. Vocal Imitation	10	155.6	11	93.0	62.6	49
III-B. Gestural Imitation	8	157.6	11	71.0	86.6	83
IV. Operational Causality	14	138.2	11	85.0	53.2	40
V. Object Relations in Space	12	140.8	11	88.0	52.8	35
VI. Schemes for Relating to Objects	2	169.0	11	90.0	79.0	45

a. The number that actually demonstrated the critical behavior for the top step.

b. In estimating the mean age, the mean age of transfer (169 weeks) has been used for those who failed to achieve top steps in the averages of the mean ages for achieving the top step.

FIGURE 1

WAVES I & II



WAVE V